SUMMARY REPORT
WORKSHOP ON POWER GRID INTERCONNECTION IN NORTHEAST ASIA

May 14th to 16th, 2001 in Beijing, China

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KEY FINDINGS AND RECOMMENDATIONS

1. BACKGROUND

- ***The public electric monopolies and oligopolies in Northeast Asia limit commercial interest in exploiting electricity trade; liberalization works in favor of border trade. ROK, Russian Far East, and PRC power sector liberalization is therefore central in determining the domestic institutional incentive to seek external power supplies.***
- ***Public institutional vehicles for cross-border transmission lines are likely a prerequisite for successful increased power trading in this region if other regional experience is any indication. Such public oversight and institutions avoid oligopolistic-motivated transmission congestion that blocks increased international power trading.***
- ***A-symmetries of size and operating characteristics of each national grid are major barriers to increased interconnection; but at the provincial level in China, Russian Far East and the two Koreas, the grids are more equal at least in scale. These obstacles therefore are not insuperable.***

2. NATIONAL PERSPECTIVES AND BACKGROUND

- ***The Russian and American analysis converged on the likely economic gains from Russian Far East-ROK power trading.***
- ***ROK-PRC (northeast province) trading gains are not yet clear due to lack of information and optimization studies.***
- ***Grid interconnection may provide low cost, low-risk hedging opportunities against domestic uncertainty about growth in supply of and/or demand for power.***
- ***The price of traded power is critical to stimulating grid interconnection.***

3. TECHNICAL ISSUES OF GRID INTERCONNECTION

- ***Detailed cost-benefit and technical-operating studies of the future of each grid with and without various inter-connections are needed to proceed further with the analysis at a regional level.***
- ***The KEDO LWRs can be operated only with regional grid supplementation to the DPRK grid.***
- ***Safe operation of the KEDO LWRs requires dedicated AC backup power supplies that are highly reliable, one of which could be a local DPRK 50-60 MW hydro-electric plant.***

4. SPECIAL TOPICS AND BARRIERS

- ***The ROK grid is already stretched to its limits to supply reliable and high quality power to demand centers (Seoul) due to the limit on 745 kVe transmission bulk shipment of power from generation surplus areas on the ROK southern coastal generation sites. The ROK can only supply limited power to the DPRK system without risking a system-wide instability in the ROK grid.***

5. FINANCING

- ***A multilateral institutional vehicle will be required both to "buffer" various parties against each other, to negotiate agreements on critical issues such as clearing prices, power allocation rules, emergency support, communication and dispatch systems, etc.***

- ***DPRK non-membership in the World Bank constrains various options at the multilateral level; an expanded mandate for KEDO is another existing possible institutional vehicle to implementing a grid interconnection project between the Russian Far East and ROK/DPRK grids.***
- ***Japanese financing via such a vehicle would likely be needed to supplement ROK financing for an RFE-DPRK-ROK transmission line.***
- ***Innovative financing using the Clean Development Mechanism might be attractive to the ROK, RFE, and PRC.***

6. NEXT STEP: NORTHEAST ASIA WORKING GROUP (NEAWG)

- ***The initial focus of the working group should be study of the Russia-DPRK-ROK transmission line due to a number of converging economic, technical, and political-security factors. It was agreed that China could play an important convening role for the initial meeting of the NEAWG.***
- ***The Russian experts indicated that they are able to produce a technical and economic optimization study of this proposed transmission line if resources to support this work are available and key data from the DPRK, ROK and PRC are provided.***
- ***The Korean delegations were positive to continuing this work***

7. DEBRIEFING

- ***The cross-cultural foundations for collaborative research and analysis have been laid for the construction of consensual knowledge on this critical energy security issue in this conflict-laden zone of the world.***

SUMMARY REPORT

This report provides a general summary of the context, objectives, and proceedings of the first workshop of the Nautilus Northeast Asia Power Grid Interconnection project (Grid project) held from May 14th to 16th, 2001 in Beijing, China. It also outlines recommended next steps for the Grid project.

The primary task for the first phase of the Grid project was to hold a regional workshop on power grid interconnection where all countries in the region including the Democratic People's Republic of Korea (DPRK) would participate. Such grid connection may be an essential element of regional energy security. In the case of the DPRK, grid connection may be a necessary condition for successful implementation of the Korean Peninsular Energy Development Organization (KEDO) strategy to transfer light water reactors (LWRs) to the DPRK to achieve nuclear non-proliferation and increase stability in Korea and the East Asian region.

The countries of Northeast Asia that could potentially be involved with a regional grid—DPRK, China, the Republic of Korea (ROK), Russia, and possibly Japan—vary widely in geographical size, population, economic strength and structure, and political structure and philosophy. Because of the diversity and complexity of national contexts and regional interactions, to date, there have been few practical collaborative regional investigations into the potential for regional power grid interconnection in Northeast Asia. The need for regional cooperation and information sharing on this subject was the driving context for organizing a workshop of regional power grid interconnection in Northeast Asia.

The workshop aimed to provide a forum for the sharing of current research related to regional grid issues among workshop participants from the region, as well as to create an opportunity to hear the perspectives from individual countries' toward potential grid interconnections. The workshop also provided training and background for regional researchers on technical issues associated with grid interconnection. This technical element was particularly valuable in providing information to North Korean experts on general issues associated with the development and operation of regional international power grids as well as on the realities of the KEDO-grid interactions and plausible ROK-DPRK grid connections. In particular, the DPRK experts have complete information on the link between grid reliability and scale and safe operation of LWRs.

1. Grid Project Objectives

The overarching aim of the Grid Project was to examine the feasibility of grid interconnection based on the actual energy and institutional situation of each country in the region.

The Grid project has several key objectives including:

- Initiating collaboration between energy policy researchers, power system experts, and engineers from the Northeast Asia region and other key areas of the world, in order to identify the potential benefits of, constraints to, and barriers in implementing electric power grid interconnections in the Northeast Asia region.

- Opening communication channels to develop a common understanding on topics associated with regional grid interconnection between national researchers in the region.
- Identifying and discussing practical procedures for achieving regional grid interconnection, for example, identifying practical financing mechanisms and necessary institutional structures.
- Providing training to energy experts from the region in key topics related to regional grid interconnection, such as aspects of international electricity trade and energy markets.
- Creating a context for friendly and meaningful ROK-DPRK dialogue and reconciliation on a significant energy security issue
- Increasing the DPRK's cognizance of critical elements of grid-LWR operational and safety issues that bear heavily on the KEDO mission in support of the US-DPRK Agreed Framework and nuclear non-proliferation goals in Korea.

2. Grid Interconnection Workshop Summary

The first workshop of the Grid Interconnection project was held in Beijing from May 14 through 16, 2001 co-sponsored by the State Power International Service and the Electric Power Research Institute of China. Power system experts, electrical engineers, economists, and energy policy researchers from all countries in the Northeast Asian region along with representatives from the United States and Europe discussed various aspects of power grid interconnection and electricity trade in the region.

2.1. Workshop co-hosts in China

The Chinese organizations that co-hosted the workshop were *the State Power International Service (SPIS)* and the *Electric Power Research Institute (EPRI)* of China. The SPIS is operated under the collaboration of the State Power Corporation, China Electricity Council and China Power Technology Import and Export Corp, with the mission of enhancing and facilitating international exchange and collaboration with China's power industry.

The EPRI is a multi-department research institute under the leadership of the State Power Corporation of China. Prof. Xie of the State Power Corporation and Dr. Zhou of the EPRI were the primary advisors for the workshop on technical issues. Mr. Liu, president of the SPIS, coordinated the workshop on-site arrangement. The co-hosts made it possible to hold the workshop under private auspices and on informal, non-governmental basis, which was an important requirement as some of agenda items were politically sensitive and related to trade issues between the countries.

2.2. Workshop Participants

The workshop participants were from China (7), Russia (2), Japan (2), South Korea (4), North Korea (4), the US, Norway and the UK. The participants brought to the workshop expertise and experience in the areas of electric power systems, electric engineering, environmental science, economics, energy policy and financing.

2.3. Workshop Agenda

The Grid Workshop was organized in five major sessions, each of which included a combination of presentations based on prepared papers or/and group discussions.

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2.3.1. Background to Regional Electricity Grid Interconnection Issues

In this session, speakers presented background on and context for possible increased electricity trade. The aim of this session was to build a basis of common knowledge among the participants that would provide a common foundation for later discussion on specific topics of grid interconnection. There were four presenters in this session.

Prof. Wangensteen from the Norwegian University of Science and Technology discussed the international context for electricity grid interconnections and regional energy networks, including driving forces and important examples of international grid interconnection. *Prof. Wu of the University of California at Berkeley and the Hong Kong University*, who is currently in charge of the study on the grid interconnection between Hong Kong and China, reviewed and discussed the Northeast Asian regional context for grid interconnection, including regional driving motivations and important areas of consideration in this regional context. *Mr. Neuhoff from Cambridge University (UK)* made a presentation on the economic considerations associated with grid interconnections. His talk provided an overview and background on power markets and pricing principles, with focus on international trading and institutional considerations. He also highlighted the topic of industry/market deregulation and its effects on electricity trades. The last speaker in this session, *Dr. Streets of Argonne National Laboratory*, provided background on the environmental considerations associated with power grid connection. He highlighted acidic deposition, mainly caused by the electric power generation with coal, as currently the most severe and immediate environmental threat in the Northeast Asian region. He also described correlations between grid interconnection and possible environmental benefits.

Key Findings

- ***The public electric monopolies and oligopolies in Northeast Asia limit commercial interest in exploiting electricity trade; liberalization works in favor of border trade. ROK, Russian Far East, and PRC power sector liberalization is therefore central in determining the domestic institutional incentive to seek external power supplies.***
- ***Public institutional vehicles are likely a prerequisite for successful increased power trading in this region if other regional experience is any indication. Such public oversight and institutions avoid oligopolistic-motivated transmission congestion blocking power trading.***
- ***A-symmetries of size and operating characteristics of each national grid are major barriers to increased interconnection; but at the provincial level in China, Russian Far East and the two Koreas, the grids are more equal at least in scale. These obstacles therefore are not insuperable.***

2.3.2. National Perspectives from the Northeast Asian Region

Dr. Padkovalnikov (Siberia Economic Research Institute, Russia), Dr. D.W. Park (Korea Electrotechnology Research Institute, ROK), Prof. Fujii (University of Tokyo, Japan), Dr. Zhou (Electric Power Research Institute, China), and Mr. Ri (Electric Power Design Institute, DPRK)

presented national perspectives regarding the possibility for regional power grid interconnection. The presentations included perspectives on: (1) Current and future contexts for electric power industries including different supply and demand, and transmission and distribution situations, (2) Economic and environmental impacts of regional grid interconnection , (3) Impacts of deregulation/restructuring/privatization of national electric power industries, (4) Costs and benefits of regional electricity trades, (5) Potential political, institutional, economic, or other barriers to interconnection of power grid, and (6) Possible financing mechanisms for grid connection projects.

The potential benefits and therefore the interest in power grid interconnection varied significantly among the different countries. Russia already has studied extensively potential grid interconnections between Far East Russia and China or Japan. Japan is concerned that their power network might be destabilized as a result of connections with outside countries. China has focused national priorities on national grid integration, rather than regional grid interconnection. ROK's interest is driven by Korean Peninsula political issues related to its historical, security and geographical position.

Several important and difficult challenges in NE Asia were mentioned by the speakers, including political and economic reliability, military tension, historical relationships, uncertainties arising from deregulation of the electricity market, and the North Korean political situation. *Peter Hayes, Executive Director of Nautilus Institute*, spelled out these issues in a frank way and provided some technical detail and overview arising from the US-DPRK Agreed Framework, the regional geopolitical context, and the DPRK energy economy and grid situation.

Many presenters cited the uncertainty associated with market deregulation in the energy sectors of Northeast Asia as a significant barrier to grid interconnection. Currently every country except North Korea is reforming their electric power industries including deregulation, restructuring, or privatization. Uncertainty as to the effects and outcomes of these reforms makes all countries hesitant to commit major resources to power grid interconnection. Conversely, most of the regional speakers agreed that if markets are liberalized and competitive market mechanisms begin to play a more active role in the region, then international electricity trade may increase due to competitive prices and hedging against domestic supply and demand uncertainty.

Despite these challenges, however, all countries (with the possible exception of Japan) are interested in electricity trade with other countries. To date, information exchange on the benefits and barriers to grid interconnection has been minimal. These uncertainties and lack of information were cited by researchers as major barriers to interconnection.

Key Findings

- ***The Russian and American analysis converged on the likely economic gains from Russian Far East-ROK power trading.***
- ***ROK-PRC (northeast province) trading gains are not yet clear due to lack of information and optimization studies.***
- ***Grid interconnection may provide low cost, low-risk hedging opportunities against domestic uncertainty about growth in supply of and/or demand for power.***
- ***The price of traded power is critical to stimulating grid interconnection.***

2.3.3. Technical Issues of Grid Interconnection

The agenda highlighted the technical and safety issues associated with connection of the North Korean power system and nuclear power plants to a national or regional grid system. In this session, two presenters discussed safety and stability concerns of power grid networks connected to the nuclear power plants. These presentations were followed by a panel discussion with power system experts for the region. In the first presentation, *Prof. Wu* discussed the range of complex technical issues arising from grid interconnection. He addressed long distance connection issues, network stability and other dynamic problems. *Dr. John Bickel*, a nuclear safety expert of the *Evergreen Safety and Reliability Technologies, LLC* detailed mandatory nuclear safety regulations and concerns associated with the operation of nuclear power plants connected to an unstable power grid network. He also had extensive side conversations with the DPRK experts (see separate attached report).

Key Findings

- ***Detailed cost-benefit and technical-operating studies of the future of each grid with and without various inter-connections are needed to proceed further with the analysis at a regional level.***
- ***The KEDO LWRs can be operated only with regional grid supplementation to the DPRK grid.***
- ***Safe operation of the KEDO LWRs requires dedicated AC backup power supplies that are highly reliable, one of which could be a local DPRK 50-60 MW hydro-electric plant.***

2.3.4. Special Topics and Barriers

In this session, speakers highlighted special topics that are unique to each country. *Dr. Ge, senior power system engineer from the Liaoning Province Electric Power Company of China*, presented the local power company's perspectives regarding potential grid interconnection of China with Russia and/or DPRK. Liaoning Province is significant in the context of regional grid interconnection, as it forms part of the Chinese national border with Russia and DPRK. A number of workshop participants questioned the current situation at the border with DPRK. The situation was described that the Yalu River, a border river with North Korea, has eight hydro-power generation units, with four of these units connected to Chinese power grid and the other four units used by the North Korean power company. *Dr. Arakawa of Global Engineering Institute* discussed the background and perspectives from the electric power companies in Japan. *Prof. Koshcheev from High Voltage Direct Current Power Transmission Research Institute of Russia* discussed the basic principles of interstate electrical power links organization in North-East Asia region. *Prof. J.K. Park from the Seoul National University* discussed the situation of power generation, transmission, and grid stability in South Korea. He described technical constraints and choices for ROK-DRPK interconnection of power grid by quantitatively illustrating the detailed situation of the South Korean power grid.

Key Findings

- ***The ROK grid is already stretched to its limits to supply reliable and high quality power to demand centers (Seoul) due to the limit on 745 kVe transmission bulk shipment of power from generation surplus areas on the ROK southern coastal generation sites. The ROK can only supply limited power to the DPRK system without risking a system-wide instability in the ROK grid.***

2.3.5. Financing

Throughout the workshop, political difficulties and financing issues were often brought up as the most crucial constraints for moving toward implementation of regional grid interconnection. In this session, three speakers made presentations on financing issues. *Dr. von Hippel,* a Nautilus research associate, outlined estimates of costs and benefits of grid interconnection. *Dr. Kim of the Korea Gas Company* explained the general background and potential for application of the Clean Development Mechanism of the Kyoto Protocol for the regional grid interconnection. *Mr. Sumi from the World Bank* presented on World Bank financing and other international institutions .

Key Findings

- ***A multilateral institutional vehicle will be required both to "buffer" various parties against each other, to negotiate agreements on critical issues such as clearing prices, power allocation rules, emergency support, communication and dispatch systems, etc.***
- ***DPRK non-membership in the World Bank constrains various options at the multilateral level; an expanded mandate for KEDO is another existing possible institutional vehicle to implementing a grid interconnection project between the Russian Far East and ROK/DPRK grids.***
- ***Japanese financing via such a vehicle would likely be needed to supplement ROK financing for an RFE-DPRK-ROK transmission line***
- ***Innovative financing using the Clean Development Mechanism might be attractive to the ROK, RFE, and PRC.***

3. Next Step: Northeast Asia Working Group (NEAWG).

In the final session, the participants discussed and concurred that the next step of the Grid project should be to create a smaller pre-feasibility working group. They suggested that such a working group could identify and detail a specific transmission line project in a pre-feasibility study. This group would specify the precise route of specific and realistic grid connection and the institutions that would be involved with this interconnection. Participants concluded that this study by a small working group is a pre-condition of further progress on grid interconnection given all the barriers.

The working group would to look closely at the impacts of the electricity security and institutional situation in each country. The study also, if possible, would need to include quantitative elements, for example: future scenarios of electricity demand and supply in each of the countries in the group, the timing (seasonality) of electricity availability by country, the status, technical parameters of, and plans for the electricity grids in each country, models and

arrangements for pricing of electricity transfers, and computer modeling of the operation of potential regional grid designs, etc.

Key Findings

- ***After much discussion, the participants concurred that the initial focus of the working group should be study of the Russia-DPRK-ROK transmission line due to a number of converging economic, technical, and political-security factors. It was agreed that China could play an important convening role for the initial meeting of the NEAWG.***
- ***The Russian experts indicated that they are able to produce a technical and economic optimization study of this proposed transmission line if resources to support this work are available and key data from the DPRK, ROK and PRC are provided.***
- ***The Korean delegations were positive to continuing this work.***

4. Final Debriefing Session

In the final session, each participant was asked to state something that he or she had learned that was surprising and/or new, and something that could have been improved in the workshop. Noteworthy at this session were heartfelt statements by ROK participants about friendly contact and exchange with DRPK participants; Chinese frank admission that they had not paid attention to the potential for grid connection in this region and that it deserved much closer study; Russian statements that they were ready to work hard to generate practical proposals with regional colleagues; and DPRK positive statements that they wished to continue to participate in such regional dialogues.

Key Finding:

- ***The cross-cultural foundations for collaborative research and analysis have been laid for the construction of consensual knowledge on this critical energy security issue in this conflict-laden zone of the world.***